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Special Industry Analysis
No. 32

ELECTRICAL EQUIPMENT

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FOREWORD

This is one of a series of Special Industry Analyses discussing from a commodity or individual industry point of view the outstanding items entering into the trade of Japan proper with its Empire and with foreign countries. These analyses are a part of a larger project which includes compilations (annotated) of the imports and exports of Japan proper by sources and destinations; surveys of certain of the colonial areas, emphasizing their Empire and foreign trade and postwar problems relating thereto; an over-all study of the trade of Japan proper; and a survey of Japan's shipbuilding industry and shipping services and requirements in the prewar period. In all of the studies Manchuria has been included as an Empire area owing to the political, economic, and military dominance of Japan in that area, especially during the last decade.

Most of the data in these analyses were taken from official and semiofficial Japanese sources. Not only have errors and inconsistencies frequently been detected within individual volumes, but many data from different sources supposedly reporting on the same subject are irreconcilable. It is very likely that large shipments of goods reportedly moving to Kwantung from Japan have been in large part merely transshipments destined for Manchuria. In addition, the data probably exclude large shipments of commodities made to and from Empire areas for military purposes.

The present report is one of a number which were prepared during 1944 and 1945 for the Foreign Economic Administration by members of the staff of the United States Tariff Commission. Owing to the desire of the Foreign Economic Administration to obtain this material as promptly as possible, the reports were not reviewed by the Tariff Commission. All statements of fact or opinion in these reports are attributable to the individual staff members who prepared them. The reports were originally intended for confidential use of government agencies, but are now being made public with the consent of the Foreign Economic Administration.

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ELECTRICAL EQUIPMENT

Introduction and summary

The leaders in manufacturing electrical equipment have been the United States, Great Britain, Germany, Japan, Sweden and Switzerland, in about that order, although Japanese products probably have been of somewhat inferior quality. These countries supply the world with electrical apparatus which the other countries are not equipped to make; they also exchange many products among themselves. By reason of better quality, larger markets, or more favorable unit labor costs due to large-scale production, they are able to compete in export markets for many of the more simple goods with countries which produce on a smaller scale.

Japan has at home the most important raw material copper; it had large well-equipped manufacturing plants, engineers, and trained workmen; and it had a wide home market for its products, based on extensive production and use of electricity in industry and in the home. It also had the advantage of a low scale of wages to strengthen its competitive position at home and abroad.

The rapid growth of the Japanese industry is apparent in the fact that the value of its output increased from 200 million yen in 1929 to 750 million in 1938. Particularly striking was the development of the heavy-equipment branch of the industry, in which the output increased from 11 million to 57 million yen. During the same period, exports of electrical goods rose from 20 million to 110 million yen, whereas imports fell from 18 million to 8 million. In 1935, about 80 percent of the exports of Japan went to Empire areas. A large part of the imports in later years was brought in only by reason of the Government's desire for speed in completing its war program. Apparent consumption expanded almost as rapidly as production; it rose from 199 million yen in 1929 to 647 million in 1938. (See table 1.)

In any limitation on the ability of Japan to make war, two branches of the electrical industry particularly must be considered:

(1) The shops--particularly the great shops--of the three leading electrical manufacturing firms--Shibaura, Hitachi, and Mitsubishi--which are equipped to make ships' turbines and innumerable electrical goods for combat material, to supply the equipment for expanding other war industries, and to convert in part to the production of heavy armament.

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(2) The firms making radios, telephones, radio tubes, and lamps.

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The three firms in the first branch are similar to the large electrical firms in the United States, although they are smaller. Each has a number of plants scattered about the country, with separate shops each devoted to the production of a group of electrical apparatus. The shops and machinery required for building heavy apparatus (steam and water turbines, generators, electric locomotives, steel mill equipment, and large motors, converters, and transformers) are so large that, if they were dismantled, they could not be replaced without the fact becoming known. In addition to the large firms already mentioned, there are three smaller ones producing similar apparatus which, though smaller than that of the three leaders, are still of substantial size.

Factories making radios, telephones, radio tubes, and lamps are closely related. The manufacture of these products is carried on partly by the three large firms already mentioned and partly by other firms. The larger companies are equipped with facilities for making semifinished components for such products, and with intricate, high-speed machines for making lamps and radio and other electronic tubes. Presumably they also have an engineering staff capable of designing and developing radio and radar apparatus essential for military use. It would not be easy, if it were desirable, to control the manufacture of radio components other than tubes, as they are made by simple equipment in many scattered homes and shops. Electronic tubes, however, cannot be made in quantity by quickly improvised machines.

The elimination of the sections of the industry making heavy equipment and electronic tubes might reduce the value of the output of the industry as a whole by 20 percent. The remainder is well suited to Japanese conditions and should be able to supply home demands, with a surplus for export to Asiatic countries. Other branches of the industry, of course, are not without military value. The wire and cable branch, usually producing, in terms of value, one-quarter of the total output in the industry, is of military significance. It would be difficult, however, to control the entire electrical industry. A Japanese directory of the industry lists about 85 firms; doubtless many more smaller firms make complete products or parts for sale to assemblers. Japan has a good supply of copper, and the variety of other required materials and their possible substitutes is so great as to preclude any practicable regulation by control of imports.

Much of the recent large colonial trade was in furtherance of the plan of the Japanese Government to industrialize the colonies in preparation for war. Moderate postwar requirements of the colonies could be supplied by the Japanese industry, or, probably at higher cost, by Europe or the United States.

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The complete elimination of the electrical equipment industry in Japan would create a rather large-size demand for imports of equipment, as the need of equipment for maintenance and peacetime development in Japan would be considerable. On the basis of prewar consumption, and considering the peacetime needs of the country after the war, imports under such conditions might be about 200 million yen.

Electrical equipment would change from an export to an import commodity in Japan's trade. Because of the critical need for encouraging industries in Japan which are adapted to the environment and resources of the country and may create export balances, it appears the more moderate control measures outlined above pertaining to heavy equipment and electronic tubes would be most advisable in this industry.

Table 1.- Electrical equipment: Production, imports, exports, and consumption, Japan proper, 1929, 1933, and 1936-38

Year	Production	Imports ^{1/}	Exports				Apparent consumption
			To	Other	Total		
			Empire areas				
1929	200.6	18.4	11.1	9.1	20.2	198.8	
1933	218.5	5.6	17.9	13.8	31.7	192.4	
1936	403.2	5.0	52.4	32.3	84.7	323.5	
1937	555.1	5.3	74.4	26.9	103.3	457.1	
1938	749.8	7.8	88.0	22.4	110.3	647.3	

^{1/} Imports from Empire areas were very negligible.

Source: Tables 3, 5, and 8.

Left in large part to itself the Japanese electrical industry probably could continue to supply almost all of the domestic needs for electrical goods, except for some of the most advanced products, and, further, provide a substantial surplus for export. Quality of output would likely lag somewhat behind that of the American and European output; exports would likely be largely of the simpler consumer goods, sold in markets where rice is the first consideration and lower quality is tolerated. PURL: <http://www.legal-tools.org/doc/5e06cf/> that the usually low individual incomes in Japan will for some time support large organizations such as those in the United States making refrigerators, cleaners, and other household appliances.

Japan's supply of copper should be adequate for normal peacetime production. Only small quantities of other needed materials would have to be imported. The colonies were never important sources of raw material for the electrical industry. They have supplied a small amount of copper, which, if needed for the industry after the war, probably could be had to better advantage from other sources.

If the Japanese industry is not limited from without, imports of electrical goods probably would be confined mostly to certain types of telegraph and telephone apparatus. In prewar years imports of these goods ranged from 1 million to 3.5 million yen annually. If production of certain heavy equipment and electronic tubes is prohibited, imports of such equipment, valued at 25 million yen annually on the basis of prewar prices, would probably be needed.

Description and uses

The manufacture of electrical equipment is an industry composed of many industries, differing widely in economic conditions and in technical requirements. The products of each branch, however, depend for their utility upon those of other branches, as any use of electricity requires means for generating it, for transmitting it, and for obtaining some useful result from it, and usually other devices, as for controlling, measuring, or modifying it.

As electrical apparatus and the conditions under which it is made vary greatly, many producers specialize in certain groups of products. Others, with large capital, produce a wide variety.

Military aspects.--The extent to which an electrical factory will be converted to other uses in war will depend on the need for the various kinds of its regular line of products, either directly as components of war material or indirectly as equipment necessary to expand the output of war industries. A large electrical firm can easily produce turbines and all the complex electrical systems for warships, telephone, radio and radar apparatus, aviation instruments, and searchlights. Other portions of peacetime production facilities can be converted to making tanks, guns, and torpedoes. In the United States some of the largest electrical firms have converted more than half of their facilities to making such products.

Heavy generating or power-station equipment.--Electricity is produced on a large scale by generators coupled to water- or steam-driven turbines, generally built as a composite unit. Because economy increases with the size of the stations and units, the trend is toward larger capacities. A million dollars or more is not an uncommon price for one machine. Firms making such machines must have heavy, expensive machinery, a large engineering organization, and ample liquid capital. Such companies are found only in industrial countries, and manufacturing of these machines is generally carried on by not more than two or three firms in each country.

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Electrical generating equipment is, of course, necessary for war economy, and may be needed in increased quantities to provide power for expanding war industries. The equipment is long-lived, however, and replacement is infrequent. Although the indirect contribution of this branch of the industry to war is a long-term meeting of the demand for more industrial power, and although lack of such equipment can be partly offset by rationing power, the industry is well fitted for direct contribution to war. Of outstanding importance are its facilities for building turbines for propelling large ships, an importance which may be judged from the fact that an American electrical company has built in 3 war years ships' turbines totaling in capacity three-quarters the capacity of those built for all purposes in the preceding 40 years. It has applied repetitive production methods to building marine turbines of 30,000 horsepower each. Such facilities are invaluable in building up a large navy or merchant marine. A shop capable of building electrical machines with a diameter of 40 feet and weighing over 1,000 tons is of great value when heavy armament is wanted.

The larger sizes of electric motors are quite similar to generators, and are usually made by the same firms.

The companies making this heavy apparatus usually make a wide variety of other electrical goods for sale to power companies and to private consumers.

Wire and cable.—Wire, bare or insulated, distributes electricity to places where electricity is needed, it spreads networks for communication, and it forms integral parts of most electrical apparatus. For carrying electricity it is generally made of copper; some is made of aluminum. For heating and other purposes, alloys of nickel, chromium, and other materials are used. For most purposes other than for long overhead lines, electrical wire must be insulated either with enamel, cotton, silk, paper, cloth, varnish, wax, oil, glass, asbestos, or some other material. Much of the cable is protected by a sheath of lead, or by a winding of steel.

Large electrical companies make wire and cable as a part of their line of electrical goods; some specialize in it, making little else. Copper-mining companies find the production of wire and cable a profitable outlet for their copper. Telephone companies needing special types manufacture their own requirements.

Wire and cable plants contribute directly to war, as large quantities of these products are required for field communication; for wiring ships, airplanes, and tanks; and for innumerable motors and instruments in combat equipment. The United States during the latter part of the war required about 300,000 miles of wire per month.

Industrial appliances.--Examples of such apparatus are welding and industrial heating equipment, electric furnaces, and portable tools. They are made by large electrical companies, and by many specialty firms. Their importance in war is in their contribution to rapid industrial production.

Telephone and telegraph equipment.--This equipment is made chiefly by telephone-carrying companies and by firms specializing in telephone, telegraph, or radio apparatus. Most of it is so unlike other electrical equipment that it is uncommon to manufacture other electrical equipment in conjunction with it.

The manufacturing equipment is generally light; the chief requirement for the industry is a specially trained personnel and adequate technical resources for routine operation and for research.

A large capacity to produce equipment of this kind is important in war, both as a source of the civilian type of equipment modified for military communication, and as a source of a highly efficient research and manufacturing organization for the development of electronic devices of great value in aerial and naval warfare.

Radio and other electronic apparatus.--In peacetime the sale of radio sets and tubes is the mainstay of this branch of the electrical industry; in highly developed countries the sale of this equipment supports large manufacturing and research organizations, which are invaluable sources of electronic apparatus for combat purposes, especially for aerial and naval warfare. The military importance of this equipment is indicated by the announced intention of the United States Government to expand the American peacetime production of such apparatus from 250 million dollars to 15 times this amount to supply war needs. The research and manufacturing organizations of large telephone companies are likely to be in a position to cooperate in supplying military electronic equipment.

Many materials are used in manufacture, among them steel, copper, brass, solder, mica, and aluminum. Wood and plastics are used for cabinets.

Radio set builders commonly maintain an engineering staff to carry on research and design the sets, and an assembly and sales organization; they buy most of the components from two groups of manufacturers, one of which makes the tubes, the other the remaining parts. Some big firms combine the three functions.

The manufacturing work is light, and is carried on partly by automatic machines and by women workers. The engineering staffs of the larger firms are likely to be capable of advanced research and potential developers of valuable military applications of electronics. Similar staffs are to be found in large telephone companies.

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As the supply of electric power increased, Japanese firms, old and new, started the manufacture of electrical apparatus, keeping always in mind the course of its progress in Western countries. Beginning about 1905, the largest United States electrical manufacturing companies probably realized that their goods would meet severe competition in Japan, with its low labor cost, tolerance for somewhat lower quality, and proclivity for copying machinery. They decided that a profitable course would be to act as financiers and teachers for the Japanese industry, taking their profits from substantial shares of ownership which they received in return for their financial and technical services.

The Mitsui and Mitsubishi families had developed great trading and industrial organizations and had taken up heavy electrical manufacturing, and with these the United States firms first concluded agreements. United States capital was put into the industry, United States patents were made available, and by exchange of engineering personnel the Japanese were given the benefit of American technical progress and manufacturing methods. At least one Japanese firm concluded similar arrangements with a leading German electrical firm. Other American firms in various branches of the industry followed the same course. As late as 1936 a well-known United States electrical company agreed to coach a large Japanese firm in the building and operation of a factory for the manufacture of instruments of American design in Japan. How well these programs succeeded is seen from the fact that in 1930 one of the largest American electrical firms closed its Japanese subsidiary, as there was no longer a market for the American-made goods of this firm. Another leading American firm was doing almost no business at that time.

Under American schooling the Japanese firms became able to build heavy apparatus which in size and quality are not far behind those made in the United States. In the volume of such equipment which they can make in a given time, however, they were far behind the large shops of the United States.

A subsidiary of Mitsubishi has become one of the two leading makers of radios, telephones, and lamps, the other being a former subsidiary of a large United States firm. Here again the Japanese companies were supplied with the best high-production machinery, and schooled in technical and manufacturing methods.

In addition to the large firms, the industry included many smaller ones of substantial size and hundreds of small home workshops, in some of which only one or two workers made some simple part for sale to assemblers. It has been estimated that in the incandescent lamp industry there were, in addition to the large factories, 300 small factories having an average of about 20 employees each, and at least 1,500 more family workshops having an average of less than 4 workers each. Most of these small factories and shops were controlled by the head of a family, who, when business was poor,

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Table 3.— Electrical apparatus production in Japan,
1929, 1933, and 1936-38

(In millions of yen)

Kind 1/	1929	1933	1936	1937	1938
Engineering equipment					
Heavy					
Water turbines and wheels	2.2	.5	4.8	6.5	8.2
Steam turbines	.8	7.2	8.3	13.6	18.3
Generators	7.9	7.7	19.1	21.1	30.8
Motors	16.0	21.6	45.1	51.0	97.6
Transformers	12.3	10.0	26.3	35.1	51.7
Locomotives	1.3	.6	1.6	1.8	2/
Total					
Other					
Telephone and telegraph	9.1	7.7	3/59.8	80.7	3/123.8
Converters	1.7	1.5	1.7	1.4	1.3
Rectifiers	.2	.3	.8	.9	2.6
Meters	2.1	7.6	8.2	12.6	17.3
Wire and cable	58.0	57.3	102.4	159.9	179.4
Cars	5.9	1.7	2.4	6.0	2/
Searchlights	2.2	.7	.1	.4	.1
Total					
Consumers' equipment					
Storage batteries	6.5	4.8	8.2	15.3	20.5
Lamps	17.7	22.0	21.4	28.3	29.4
Heaters	1.9	1.4	2.5	4.0	3.3
Fans	1.7	.9	1.7	2.6	2.6
Clocks	.3	.2	1.0	2.7	2.1
Dry cells	5.9	6.6	8.3	11.2	17.0
Lighting goods	2.5	6.9	10.7	17.9	17.6
Radios	4.7	19.3	4/	4/	4/
Total					
Other	39.6	39.2	79.5	99.5	143.8
Grand total	200.6	218.5	403.2	555.1	749.8

1/ Some kinds of apparatus, such as motors, fall partly in 2 or more of the general classes shown, depending on individual sizes and characteristics.

2/ Not available.

3/ Includes radios.

4/ Included in telephone and telegraph equipment.

Table 4.- Electrical apparatus: Imports into Japan, by kinds,
1928, 1929, 1933, and 1936-38

Kind	(In thousands of yen)					
	1928	1929	1933	1936	1937	1938
Insulated wire and cable:						
Submarine telegraph	658	1,685	-	-	-	-
Other insulated	539	257	75	95	148	38
Meters, ammeters, voltmeters, and wattmeters 1/	973	1,235	178	173	214	57
Batteries	354	422	106	100	52	44
Telegraph apparatus	894	930	364	151	124	1,594
Radio apparatus	594	568	338	350	409	100
Telephone apparatus	2,494	2,323	2,269	792	1,405	1,784
Generators and motors	6,415	6,831	1,735	1,669	1,669	2,589
Transformers	1,015	653	65	136	170	177
Generator-prime mover sets	349	1,325	113	102	19	119
Steam turbines and parts	499	1,098	343	1,385	1,054	1,110
Water turbines	559	1,002	16	8	163	
Total	15,343	18,422	5,606	4,908	5,272	7,775

1/ Another classification "other meters" may contain an unknown amount of electric meters. The total imports under this classification are large (2,063,000 yen in 1929 and 1,838,000 in 1928).

Source: Official trade statistics of Japan.

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Table 5.- Electrical apparatus: Imports into Japan,
by countries, 1928, 1929, 1933, and 1936-38

Country	(In thousands of yen)					
	1928	1929	1933	1936	1937	1938
United States -----	6,990	7,678	1,340	1,294	2,324	3,476
Great Britain -----	2,371	3,393	713	1,163	236	221
Germany -----	4,084	5,100	2,919	1,588	2,156	3,602
Sweden -----	167	400	173	304	50	156
Switzerland -----	1,289	907	267	527	416	276
France -----	180	95	88	33	3	13
All other -----	262	849	106	59	87	31
Total -----	15,343	18,422	5,606	4,968	5,272	7,775

Source: Official trade statistics of Japan.

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Exports

Exports expanded rapidly in the decade 1929-39; in 1929 they had amounted to only 20 million yen, but by 1937 had passed the hundred million yen mark, and by 1939 totaled 135 million yen. This total ranks among the larger exports from Japan, and, as the raw materials needed to make these products are to a large extent available in Japan or not very costly to import, the amount of exchange created by such exports was, at least in theory, ^{1/} considerable.

Most of the exports were to Empire areas, especially Kwantung and Korea. Those to Kwantung were in large part probably for shipment inland to Manchuria. Of the non-Empire areas, China received large quantities, although the United States, British India, and the United Kingdom were also important markets. Some nonindustrial goods--incandescent lamps, sockets, flashlights, and lighting fixtures--went mainly to Great Britain, the United States, China, and South America. Total exports of these items decreased or remained stationary from 1936 to 1938, whereas exports of industrial goods, going mostly to Empire areas, increased (shipments to Manchuria and Kwantung were largely capital goods in furtherance of the program for building up sources of supply in favorable locations within the Empire). (See tables 7, 8, and 9.)

It does not seem probable that Japan would, in the near future, export the more highly technical goods, especially to Western countries even were it allowed to do so. Such goods, examples of which are large turbo-generators, meters, telephone and some types of radio apparatus, and switch-gear, are bought mostly by large corporations which are likely to insist on high quality and on buying from firms of recognized reputation, rather than on low price. They might, however, be sold in Asia.

Other classes of goods are sold directly or indirectly to small consumers, many of whom are not in a position to judge or appreciate quality and who buy more largely on the basis of price. These goods consist mostly of simpler types. Probably Japan could export a relatively small quantity for sale at the low-price end in the more discriminating markets, such as the United States and Europe, and a larger quantity for sale in the less discriminating markets. Examples of such goods are flashlights, dry batteries, wiring devices, small motors, lamps, and household appliances. Low labor rates give Japan an advantage in exporting these goods to certain areas in competition with Western nations.

^{1/} It is noted that a large part of the exports were to yen areas.

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Table 8.- Electrical equipment: Exports from Japan,
by countries, 1929, 1933, and 1936-39

(In thousands of yen)

Country	1929	1933	1936	1937	1938	1939 1/
Empire areas:	:	:	:	:	:	:
Kwantung	5,334	10,467	24,622	40,800	54,431	-
Korea	4,499	4,518	19,828	23,969	18,153	30,393
Manchuria	10	739	2,288	4,593	9,907	-
Formosa	1,255	2,170	5,675	5,028	5,466	-
Total	11,098	17,894	52,413	74,390	87,957	-
Non-Empire:	:	:	:	:	:	:
China	2,675	2,071	6,566	7,369	13,041	-
United States	2,846	3,070	4,617	4,406	1,704	-
British India	581	1,425	3,740	3,688	1,322	-
Great Britain	617	2,023	2,429	2,620	1,370	-
Netherlands Indies	292	708	840	1,222	683	-
Argentina	113	389	565	896	442	-
Asiatic Russia	168	182	3,519	828	34	-
Russia in Europe	2	-	4,098	396	6	-
All other	1,840	3,904	5,876	7,501	3,780	-
Total	9,134	13,772	32,250	28,926	22,382	-
Grand total	20,232	31,666	84,663	103,316	110,339	140,893

1/ Country distribution, other than Korea, not reported. Exports to Formosa not available.

Source: Official statistics of Japan, Korea, and Formosa.

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Table 2.- Electrical equipment: Exports from Japan, by kinds and countries, 1929 and 1936-Continued

(In thousands of yen)

Kind	Manchuria and Kwantung	Korea	Formosa	China	British India	United States	Great Britain	All other	Total
1936:	:	:	:	:	:	:	:	:	:
Copper wire, bare -----:	5,427	1/	1/	459	249	1/	1/	29	6,164
Copper wire, insulated -:	15,951	6,001	1,638	3,599	108	1/	13	216	27,526
Meters and parts -----:	2,547	1/	1/	415	8	4	4	119	3,097
Batteries ---:	2,235	1/	1,001	592	11	4	1/	391	4,234
Telegraph apparatus -:	1,705	)	)	220	1/	1/	1/))
Telephone apparatus -:	(2,797)	646	)	748	3	1/	1/	41	13,111
Radio apparatus -:	6,984	)	)	258	6	1/	1/))
Generators and motors -:	7,186	6,211	1/	3,004	28	1/	1	137	16,567
Transformers -:	5,301	1/	1/	794	3	1/	2	17	6,117
Switchboards and switchgear -----:	3,960	1/	1/	715	21	1	1/	13	4,700
Other electrical machinery -:	4,915	1/	1,684	424	2	1/	6	103	7,124
Electric fans -----:	527	1/	1/	270	248	1/	1/	99	1,144
Signal apparatus -:	1,162	1/	1/	1	1/	1/	1/	1	1,164
Incandescent lamps -----:	1,028	1,327	1/	652	269	1,477	88	3,184	8,025
Flashlights -:	145	1/	1/	89	5	40	120	310	709
Fixtures, portable -:	1/	1/	1/	1/	1/	1/	1/	1/	1/
Lamps, socket, etc -:	919	1/	1/	289	270	167	375	546	2,566
Other electrical goods -:	1/	1/	496	1/	1/	1/	1/	1/	498
Insulators and electrical porcelain -:	1/	1/	1/	1/	1/	1/	1/	1/	1/
Electrical porcelain -:	2,067	1,817	1/	506	98	11	9	184	4,392
Carbon -----:	368	1/	1/	17	1/	1/	1/	84	462
Total -----:	64,337	18,153	5,466	13,041	1,322	1,704	1,370	6,562	110,339

1/ Not separately reported.

Source: Official trade statistics of Japan, Korea, and Formosa.